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C65-8630

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
Exhibit E, Para.5.10	13	LEM	NAS 9-1100	14 Jan.1963

Type I NASA APPROVAL PENDING

Primary No. 664

REPORT

NO. LPL-540-1, Amendment 1 DATE: 27 September 1963

MISSION PLAN [U]

CODE 26512

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CLASSIFICATION CHANGE
To UNCLASSIFIED
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REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

~~AVAILABILITY ONLY~~

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GROUP 4. DOWNGRADED AT 3 YEAR INTERVALS: DECLASSIFIED AFTER 12 YEARS

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CORRECTION AND AMENDMENT TO

LPL-540-1

These comments are to be incorporated into the existing Mission Plan.

Section

II A *Table II-1C. The phase described here (360 minutes in Table II-2) does not represent the entire countdown. Further clarification from MSC is pending.

*Table II-1F. The thrusting out of earth orbit is defined by MSC as "Translunar injection" not "translunar insertion".

*Table II-1L. Should be called "Lunar Surface Stay" to differentiate from orbital stay times.

II B *Table II-2G. 36.0 minutes should be 35.0 minutes.

*Table II-2G-1. 6.0 minutes should be 5.0 minutes.

*Table II-21-1. The time required for jettisoning the S-IV-B is undetermined at this time, but 20 minutes is excessive.

*Table II-21-2. The requirement for checkout at this time is undetermined, but 60 minutes is probably excessive. See III-1-2.

*Table II-21. Mid-course corrections by the CSM should be denoted here as a sub-phase.

*Table II-2M-7. This should read "Transfer Crew and Payload."

Figure II-1. Alter as shown below.

G - Translunar Injection and Initial Coast T = 192 min. to T = 227 min.
H - Transposition T = 227 min. to T = 257 min.
I - Final Coast T = 257 min. to T = 4937 min.
J - Lunar Orbit T = 4937 min. (82.28 hrs) to T = 5090 min. (84.83 hrs).
K - Descent T = 5090 min. to T = 5260.5 min. **
M - Ascent T = 0 to T = 123.1, home in CSM from 20 n. mi.

II C Navigation and Guidance - para. 1 "analog error" should be "analog".

*Delete paragraph 5 and substitute "The Alignment Optical Telescope, AOT, supplies the angular position of celestial bodies which are used for IMU fine alignment. The Fixed Reticle (FR) is part of the window and is used by the pilot to visually acquire a programmed landing site, or to select an alternate landing site."

** The MSC Reference Mission Plan will eliminate the full synchronous orbit coast prior to powered descent.

Section	
II C	*Stabilization and Control - para 6 - "Thrust controllers" should be "translation controllers."
	Main Propulsion - para 2 - Delete last sentence, and substitute "The descent engine is radiation/ablative cooled. It has a maximum thrust of 10,500 lbs., and a minimum thrust of 1,050 lbs."
	*Communication - The word "section" should be replaced by "equipment".
	Para 1 - Delete " . . . 6) range-to-earth information. The . . . from Earth" and substitute "The S-Band equipment can receive voice and ranging inputs from Earth and automatically re-transmit the ranging information back to the Earth."
	Para 2 - Change 9) to read "an omni-directional antenna." Delete 10).
	Para 4 - Change " . . . consisting of . . . and a receiver" to " . . . consisting of redundant transmitters and receivers . . ."
	*Instrumentation Subsystem - para 1 - Delete last sentence. Substitute - "The central timing function of the LEM is included as part of the PCM unit. The entire unit is referred to as the PCMTE."
	*Structure and Landing Gear - para 2 - The separation system also provides for separation of hydrogen lines.
III B	Last paragraph - delete last sentence.
III C	Paragraph 1 - Delete second sentence and substitute "The service structure is cleared of personnel, and the pyrotechnics are checked. At this time, it is felt that the pyrotechnics should be checked prior to fueling with hypergolics. The personnel are . . ."
	Table III-1 - Change UHF to VHF.
III D	*Delete last sentence. Substitute "The LEM remains passive until the trans-lunar checkout phase, except for the temperature control of the IMU which requires the Electrical Power Subsystem, and the coolant loop of the Environmental Control Subsystem to be operative."
III E	Line 1 - Change "LEM" to "LES".
III F	*Add "For purposes of subsystem design, 270 minutes in earth orbit must be assumed since other aspects of the Apollo mission provide for Earth orbit stay of this duration.
III G-2	*Docking is allowed in the radiation belts. The only constraint on operation through the belts is that crewmen cannot enter the CM tunnel until 30 minutes after injection.

Section	
III I-1	*Para 2 - Delete "it is assumed . . . control of the IMU." Substitute "Temperature control of the IMU is required during the translunar phase. This entails the use of the EPS and the coolant loop of the ECS."
III I-2	Table III-3 - Change UHF to VHF.
III I-3	*Change "gyro heaters" to "IMU heaters".
III J-1	Change "Apollo Spacecraft" to "LEM/CSM".
III J-2	*The CM performs landmarks and star horizon measurements for orbit determination.
	Table III-4 - Change UHF to VHF
III J-3	Table III-5 - Change UHF to VHF
III K-1	*Figure III-5 - Some of the orientations here and elsewhere are to prevent sunlight from directly striking the LEM windows.
	NASA has directed GAEC to design the LEM "independent of thermal constraints", including lunar stay in full sunlight. This should be construed to mean that the LEM is to have no preferred orientations with respect to the Sun during the mission. Therefore, delete Figure III-5.
	Table III-7 - Change UHF to VHF.
	*The 5 fps delta-V specified is used to separate the LEM from the CSM by a distance of 100 ft. At the completion of the maneuver, zero relative velocity exists between the LEM and the CSM.
III K-2	Table III-8 - Change UHF to VHF.
III K-3	*The rotational limits specified for the LEM are based on a ± 65° limit on the excursion of the middle gimbal of the IMU. This limit arises from "gimbal lock" considerations. In terms of the LEM body coordinates, there is a ± 65° limit on rotations about the Z axis, or a ± 65° limit on rotations about the Y axis after ± 90° rotation about the X axis.
	Figure III-8 - Delete "injection into synchronous orbit 94° from lunar injection point."
	Table III-9 - Change UHF to VHF.
III K-4	*The LEM does not sight on landmarks because the fixed telescope has only single power optics. The descent transfer orbit ephemeris is to be determined by using the CM radar to track the LEM and/or LEM radar to track the CM. This applies also to Figure III-9, Figure III-10, and Figure III-11.

Section	
III K-4	Replace Figure III-9 with Figure III-9' which is enclosed.
	Delete Figure III-12 as per comment of section III-K-1.
	Table III-10 - Change UHF to VHF.
III K-5	Table III-11 - Change UHF to VHF.
III K-6	*The nominal trajectory for this phase is a constant-thrust, minimum-fuel trajectory calculated with the GAEC "Gradient Program". The initial thrust-to-weight ratio for this trajectory is 0.396 which, for a LEM weight of approximately 23,000 lbs., results in a constant thrust of 9150 lbs. By performing the powered descent with lower than maximum thrust level, the excess available thrust can be used to correct perturbations in the trajectory.
	The delta-V expenditure for the 238 seconds of flight is 3620 ft./sec., based on a specific impulse of 310 sec.
	It has been agreed by MSC and GAEC that 305 secs should be used for the descent stage specific impulse and 303 secs for the ascent stage specific impulse. It is not expected that this change in Isp will have a significant effect on the delta-V.
	*Table III-12 - "Reaction Control" and "Descent Engine" should be separated as in the other tables.
	Table III-12 - Change UHF to VHF.
III K-7	Both pilot control and translation capability are enhanced by a powered descent trajectory whose final phase may be described as "The LEM passes through 1,000 feet altitude with a low descent rate and a horizontal velocity less than 100 fps." Study in this area is proceeding at the present time.
	Table III-13 - Change UHF to VHF.
III K-8	*Figure III-23 - Minimum thrust is 1050 pounds, not 1000 pounds as the figure seems to indicate.
Delta-V Summary for Descent	*Table III-15 - The delta-V budget values shown here are the recommended LEM delta-V budget for each phase of the nominal mission as agreed upon by GAEC and NASA. A detailed breakdown of these values, along with the positive and negative uncertainties with respect to the nominal delta-V are included in GAEC LEM Engineering Memo, LMO-500-37, 22 April 1963. The nominal trajectory delta-V values shown are for the specific trajectories shown in LPL-540-1.

III K-8 Table III-14 - Change UHF to VHF.

*Table III-14 - The backup guidance system will be in operation during all power flight phases for monitoring and to allow instantaneous use.

III L *The 23 hours lunar surface stay shown is 1 hour short of the 24 hours desired by NASA. If the translunar checkout is eliminated or decreased, or if the extra equiperiod orbit is eliminated, the 24 hours could be attained. A surface stay time of 24 hours should include more than 2 excursions. One PLSS can be replenished during the second exploration. Excursions should be planned for three hours duration with one hour contingency.

III L-2 Table III-17 - Change UHF to VHF.

III L-3 Table III-18 - Change UHF to VHF.

III L-6 *Table III-19 - It can no longer be assumed likely that the LEM optics will be able to track the CSM from the lunar surface since the AOT does not have hemispherical coverage. In most cases, the LEM optics will point away from the CSM as it comes up from the lunar horizon. Change UHF to VHF.

III M-1 Table III-20- Change UHF to VHF.

III M-2 Table III-21 - Change UHF to VHF.

III M-3 Table III-22 - Change UHF to VHF.

III M-4 Table III-23 - Change UHF to VHF.

III M-5 Table III-24 - Change UHF to VHF.

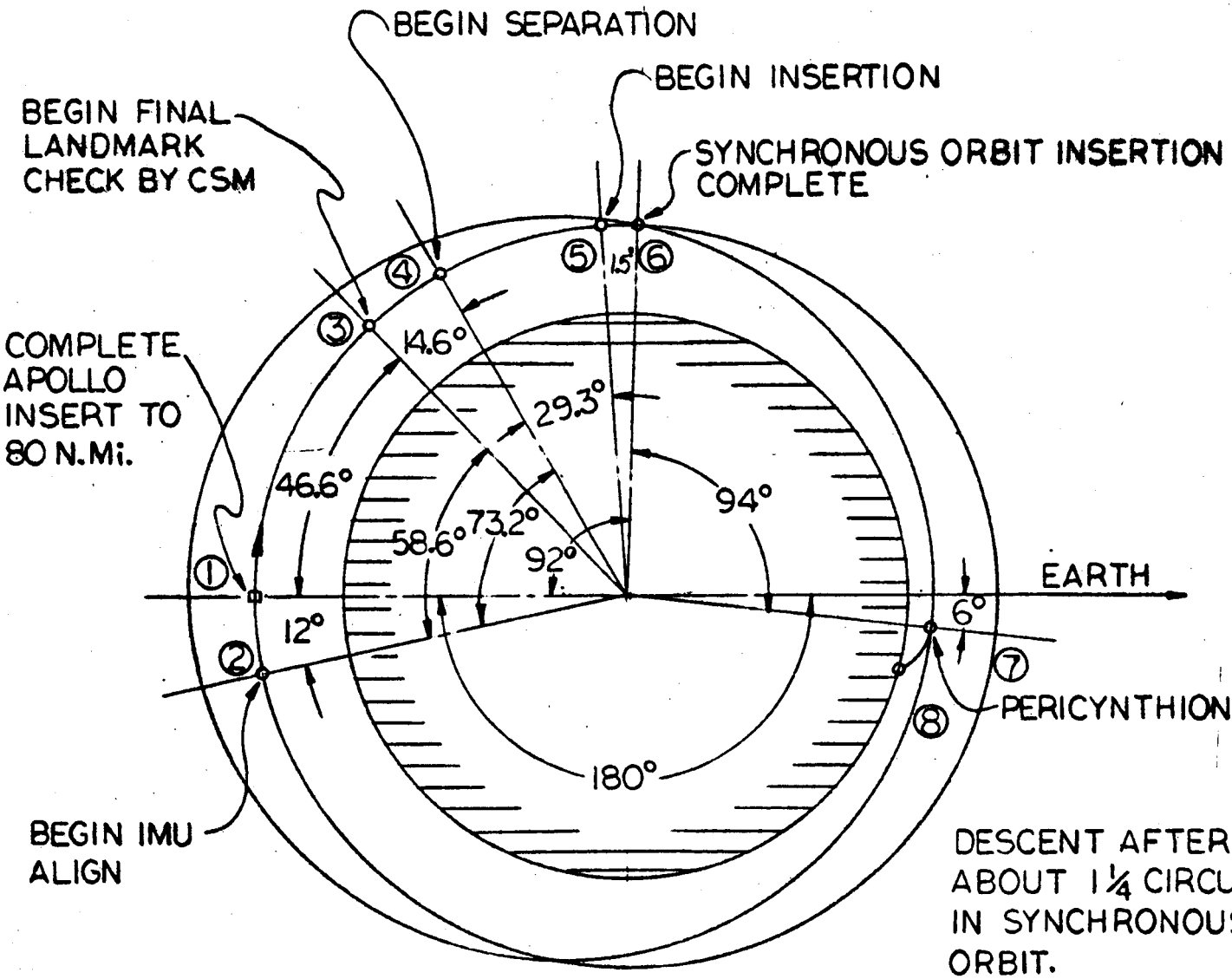
Delete the last paragraph on page III-94 and Figure III-32 since the errors indicated for the thrust variations shown are not based on the pitch program of Figure III-27.

III M-6 The automatic docking section should be deleted as impractical.

Table III-25 - Change UHF to VHF.

Delta-V Summary for Ascent * Table III-27 - See comments on Delta-V Summary for Descent. The nominal trajectory data shown here are for the specific trajectories indicated. These data do not include mid-course correction, or 2° plane change capability, as does the "Delta-V Budget".

Section	
IV	*The electrical power requirements shown do not agree with the latest GAEC load analysis since the power required for the coolant loop of the ECS, and the EPS during translunar flight is not included. At the present time, the LEM is required to support temperature control of the IMU, and all equipment needed for this function is on during translunar flight. See GAEC drawing LDW-390-10000-A, LEM Load Analysis.
IV-5	Phase time for L-3 is 360 minutes. The title of phase L-3 should be Report and Replenish PLSS. See comments on phase III-L.
V-D	Table V-2 - A revised critical subsystem design mission for the EPS is currently under study by GAEC.
V-D.1.b	*This statement is right in general, but some cases will exist where the mission would be continued, possibly under altered plans. For instance, if the primary N and G subsystem fails during the final descent phase, it may be that crew safety and mission success probabilities would be enhanced by completing the landing, followed by a shortened lunar stay with limited exploration.
V-D.6.4	*It should be explained that the VHF link through the CM provides only for voice communication.



ORBITAL RATE: 2.93°/MIN.

NOTE-THE MSC REFERENCE MISSION PLAN WILL ELIMINATE FULL SYNCHRONOUS ORBIT COAST PRIOR TO POWERED DESCENT

FIG. III-9'

NEAR-MOON GEOMETRY

(CORRECTION TO MISSION PLAN LPL-540-1)

TREFFEISEN

ENCLOSURE (2)

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COMMENTS INCLUDED IN NASA LTR SLE-13-63-300

REVIEW OF GAEC REPORT NO. LPL-540-1

9 SEPTEMBER 1963

Section

III I-2 NASA stated in LTR SLE-13-63-300 that "Checkout of the N and G subsystem at this point (in the mission) is not justified. Checkout should not occur until just prior to planned use."

GAEC feels that a judgement of this sort is premature since the evaluation of the effects of in-flight repair of the computer, and a definition of alternate lunar "fly-by" missions is not complete at this time.

III I-3 In NASA LTR 13-63-300, GAEC was directed to provide a 110 hr. translunar trip capability in the LEM. GAEC is presently studying the effects on the cost, weight and reliability of the LEM. GAEC considers that an increase in the control weight of 26,800 lbs. of the LEM (see LEM Report 490-2) will be required in order to incorporate the capability for a 110 hr. trip time, if this is to be imposed as a design requirement.

III K-6 Table III-12 - NASA recommends that the ascent propellant system be pressurized during descent to provide a rapid abort capability. GAEC feels that the ascent propellant system should not be pressurized until the ascent engine is actually required to operate, since long periods of pressurization decrease reliability and landing with pressurized tanks poses an additional crew safety hazard.

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